

AD-A160 913

TE2 CHEMILUMINESCENCE FROM ALKALI ATOM-TEC14 REACTIONS

1/1

(U) NEW HAMPSHIRE UNIV DURHAM DEPT OF PHYSICS

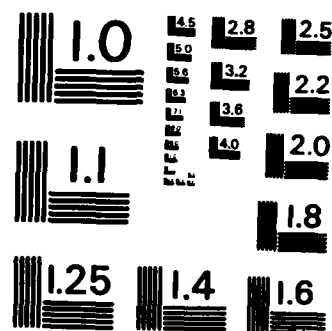
K K LIN ET AL. 29 OCT 85 ONR-TR-4 N00014-83-K-0533

UNCLASSIFIED

F/G 7/5

NL





MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

11

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER ONR-TR-4	2. GOVT ACCESSION NO. AD-A160913	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Te ₂ Chemiluminescence from Alkali Atom-TeCl ₄ Reactions	5. TYPE OF REPORT & PERIOD COVERED Interim Technical Report	
6. PERFORMING ORG. REPORT NUMBER		
7. AUTHOR(s) K. K. Lin, L. C. Balling and J. J. Wright	8. CONTRACT OR GRANT NUMBER(s) N00014-83-K-0533	
9. PERFORMING ORGANIZATION NAME AND ADDRESS Department of Physics University of New Hampshire Durham, N.H. 03824		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS NR-051-847
11. CONTROLLING OFFICE NAME AND ADDRESS Office of Naval Research Department of the Navy Arlington VA 22217		12. REPORT DATE October 29, 1985
		13. NUMBER OF PAGES 8
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		15. SECURITY CLASS. (of this report) Unclassified
		16. SECURITY CLASS. (of this report) Unclassified
16. DISTRIBUTION STATEMENT (of this Report) Approved for public release; reproduction is permitted for any purpose of the United States Government; distribution unlimited.		
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report) Distribution of this document is unlimited.		
18. SUPPLEMENTARY NOTES Accepted for publication in Chemical Physics Letters		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) Chemiluminescence, Te ₂ , Alkali Atom Reactions		E
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) The gas phase reaction between alkali atoms and TeCl ₄ produces chemiluminescence from the A state of Te ₂ . The observed transitions are from V' = 0 - 5 of the A state to V'' = 3 - 20 of the X state.		

AD-A160 913

OTIC FILE COPY

DTIC
ELECTE
NOV 01 1985
E

OFFICE OF NAVAL RESEARCH

Contract N00014-83-K-0533

Task No. NR-051-847

TECHNICAL REPORT NO. 4

Te₂ Chemiluminescence
from Alkali Atom-TeCl₄ Reactions

by

K.K. Lin, L.C. Balling, and J.J. Wright

Accepted for publication

in

Chemical Physics Letters

University of New Hampshire
Department of Physics
Durham, NH 03824

October 29, 1985

Reproduction in whole or in part is permitted for
any purpose of the United States Government

B5 11 01 033

Te_2 Chemiluminescence from Alkali Atom- TeCl_4 Reactions*

K.K. Lin, L.C. Balling, and J.J. Wright

Physics Department

University of New Hampshire

Durham, NH 03824

Accession For	
NTIS GRA&I	<input checked="" type="checkbox"/>
DTIC TAB	<input type="checkbox"/>
Unannounced	<input type="checkbox"/>
Justification	
By	
Distribution/	
Availability Codes	
Dist	Avail and/or Special
A-1	

Abstract



The gas phase reaction between alkali atoms and TeCl_4 produces chemiluminescence from the $\text{A}(\text{O}_u^+)$ state of Te_2 .

* This work was supported by the Office of Naval Research.

In this Letter we report the observation of visible chemiluminescence from the $A(O_u^+) \rightarrow X(O_g^+)$ transitions of Te_2 produced in alkali atom- $TeCl_4$ reactions.

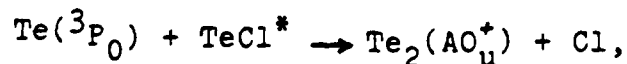
The reactions took place in a 500 ml Pyrex flask connected to a vacuum-gas-handling system. $TeCl_4$ crystals were contained in a sidearm connected to the cell. Alkali metal (K, Rb, or Cs) was distilled into the cell, the entire cell was heated to produce an alkali atom pressure in the range 10^{-3} -1 Torr, and then the $TeCl_4$ crystals were melted to produce a vapor pressure in the 1-10 Torr range. The resulting reaction produced a yellow flame which filled the entire volume of the cell. The addition of helium gas resulted in a red flame. The chemiluminescence was observed and recorded with an optical multichannel analyser (OMA) with a spectral range of 200-700 nm and a resolution of 0.5 nm per channel.

Fig. 1 shows the spectrum from the reaction of Cs with $TeCl_4$. The wavelengths for the vibrational bands correlate with transitions from the $A(O_u^+)$ state of Te_2 . Fig. 2 shows the relevant potential energy curves for Te_2 [1]. These curves indicate the complexity of the Te_2 spectrum. Numerous transition wavelengths from both the A and B states [2] overlap to within the ± 0.5 nm resolution of the OMA. Using the RKR potential curves of Fig. 2 as a guide, the best fit to the spectral data appears to be transitions from $v'=0-5$ of the $A(O_u^+)$ state to $v''=3-20$ of the $X(O_g^+)$ ground state.

We reject the possibility of the chemiluminescence originating from $B(O_u^+) \rightarrow X(O_g^+)$ transitions because the observed spectrum cuts off at ~ 500 nm. $B(O_u^+) \rightarrow X(1_g)$ transitions are not ruled out directly, but one would not expect to see them without the $B(O_u^+) \rightarrow X(O_g^+)$ transitions as well.

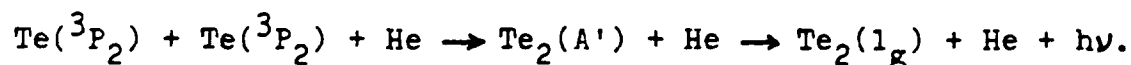
The addition of 1-3 Torr of He to the reaction cell radically changed the character of the chemiluminescence. The flame became red, and the spectrum was a structureless continuum from 550-750 nm, with a peak at ~ 650 nm. This spectrum is similar to those observed in rare-gas matrices and attributed to $A'(^3\Sigma_u^+) \rightarrow X(1_g)$ transitions [3,4].

A similar change in chemiluminescence due to the addition of a buffer gas has been observed for alkali atom- SCl_2 reactions [5], which produce excited S_2 molecules, and we believe that similar mechanisms are responsible for the formation of excited Te_2 . The $X(O_g^+)$, $X(1_g)$, and $A'(^3\Sigma_u^+)$ states of Te_2 correlate with two $Te(^3P_2)$ atoms, and the $A(O_u^+)$ state correlates with $Te(^3P_2)$ and $Te(^3P_0)$ atoms. The 3P_0 state is ~ 4750 cm^{-1} above the 3P_2 state. It is proposed that the following reaction is responsible for the formation of excited Te_2 in the absence of a buffer gas:



where the excited $Te(^3P_0)$ and vibrationally excited $TeCl$ result from energy liberated in the alkali atom stripping reactions.

When helium gas is added to the reaction cell, the energy liberated from the stripping reactions is rapidly dissipated in collisions with the gas. In the absence of energy storage, the stripping reactions produce only ground state $\text{Te}(^3\text{P}_2)$ atoms. We therefore propose that the structureless red-shifted spectrum observed is a three-body recombination continuum:



We note, in conclusion, that the chemiluminescent reactions reported here might be applicable to the construction of a chemical electronic-transition laser. The excited-state potentials of Te_2 are displaced from the ground state potentials, as shown in Fig. 2, and continuous laser oscillation of optically pumped Te_2 has been achieved for $\text{B}(0_u^+) \rightarrow \text{X}(0_g^+)$ transitions [6]. The Te_2 $\text{A} \rightarrow \text{X}$ transitions observed in this experiment are to $v''=3-20$ of the X state and the v' levels of the A state have comparable, or longer, lifetimes than those of the B state [7,8], making this system a potential laser candidate.

References

- [1] J. Verges, C. Effantin, O. Babaky, J. d'Incan, S.J. Prosser, and R.F. Barrow, Phys. Scripta 25 (1982) 338.
- [2] K.P. Huber and G. Herzberg, Molecular spectra and molecular structure, Vol. 4, constants of diatomic molecules (Van Nostrand, Princeton, 1979).
- [3] V.E. Bondybey and J.H. English, J. Chem. Phys. 72 (1980) 6479.
- [4] F. Ahmed and E.R. Nixon, J. Mol. Spectry. 87 (1981) 101.
- [5] J.J. Wright and L.C. Balling, Chem. Phys. Letters 108 (1984) 214.
- [6] B. Wellegehausen, D. Friede, and G. Steger, Opt. Comm. 26 (1978) 391.
- [7] J. Cariou, Y. Guern, J. Lotrian, and P. Luc, J. Phys. B15 (1982) L841.
- [8] R.S. Ferber, O.A. Shmit, and M. Ya. Tamanis, Chem. Phys. Letters 92 (1982) 393.

Figure Captions

Figure 1. Chemiluminescence spectrum of Te_2 from the reaction $\text{Cs} + \text{TeCl}_4$.

Figure 2. Energy level diagram for Te_2 (ref. [1]).

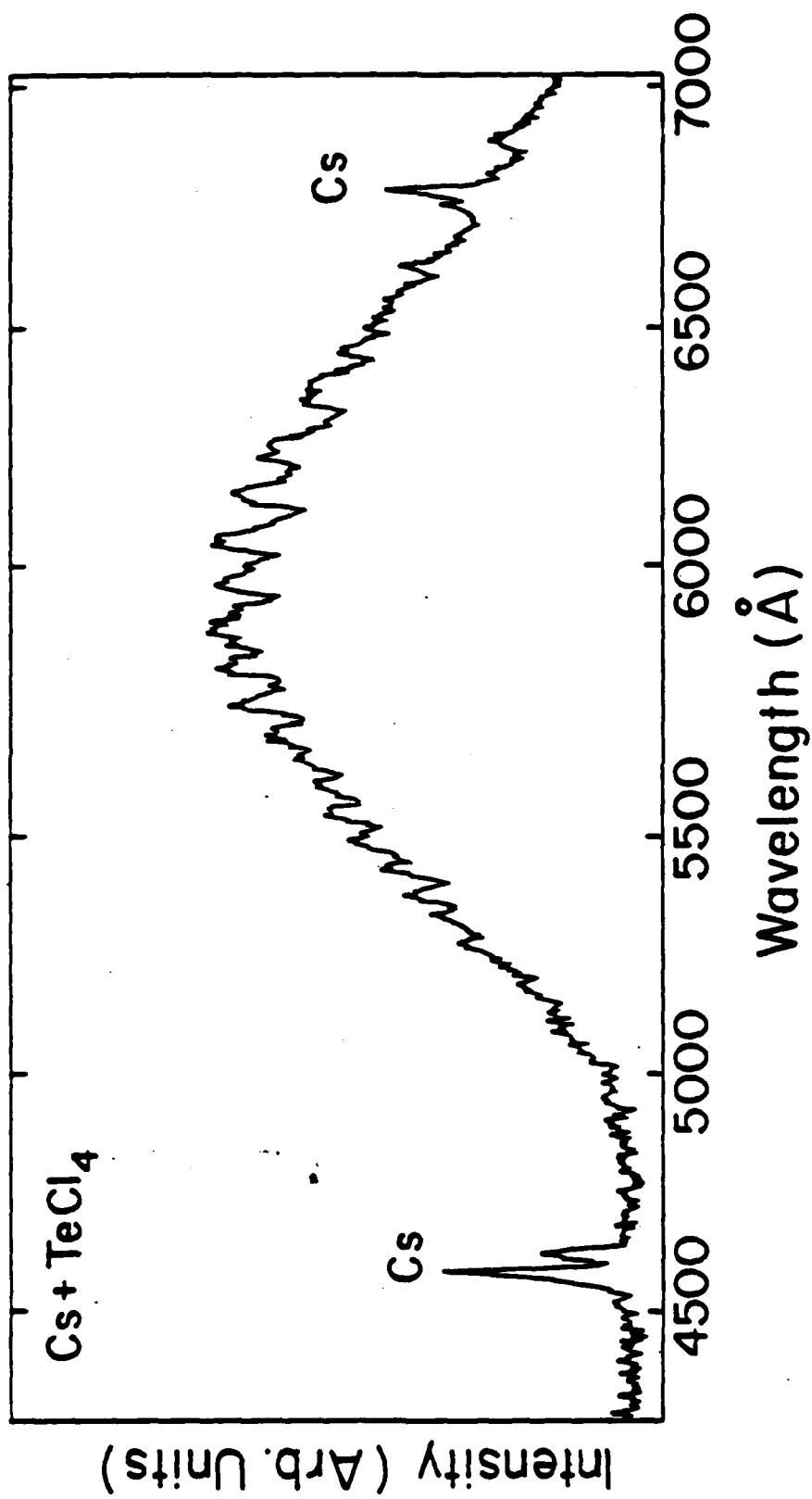


Fig. 1

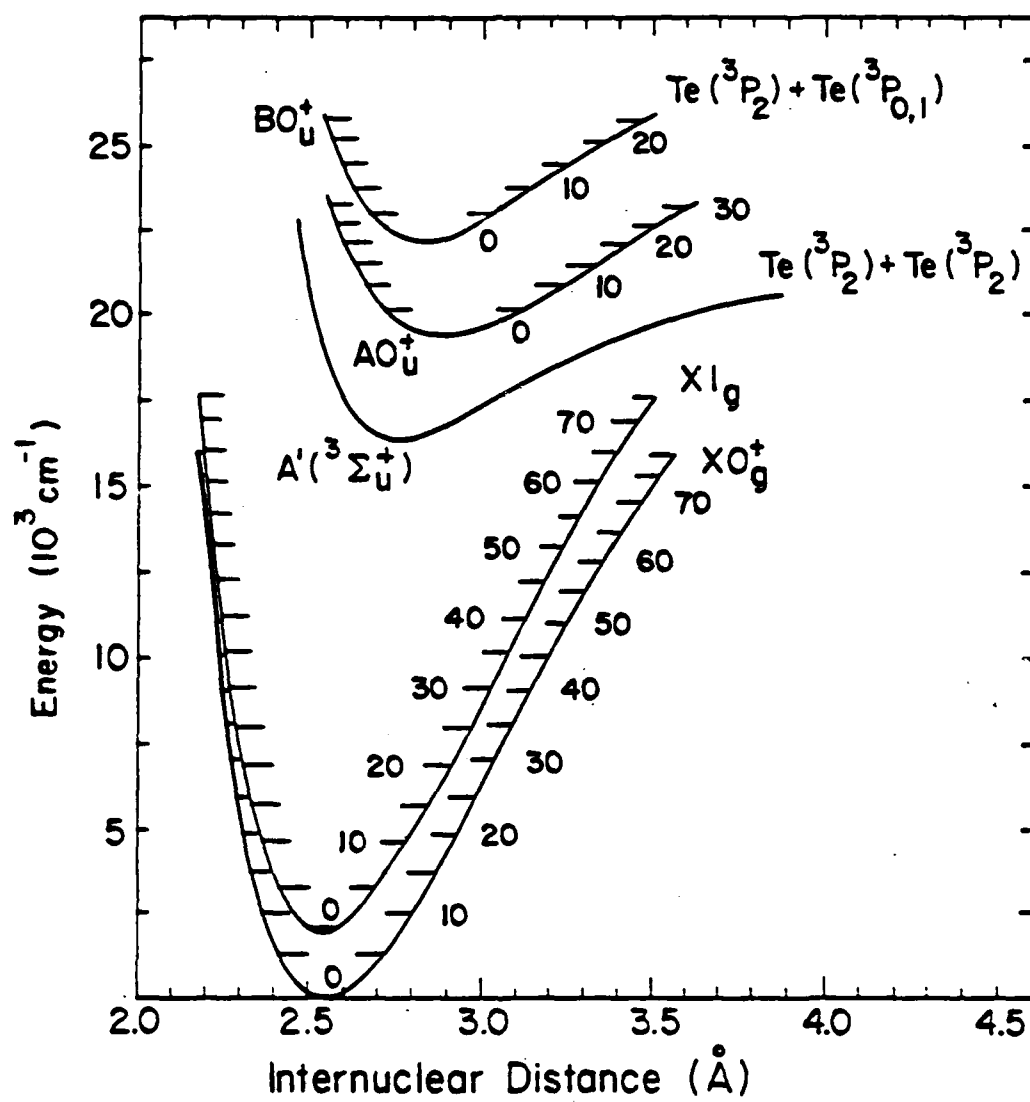


Fig. 2

END

FILMED

12-85

DTIC